(12) **DESCRIPTION OF AN INVENTION**
for the Russian Federation patent

(54)   **METHOD FOR BASALT FIBER PRODUCTION AND DEVICE FOR ITS ACCOMPLISHMENT**

This invention is related to production of the mineral fiber from the natural material of basalt group. Method of the basalt fiber production includes batching of the basalt into the smelting furnace, its melting and stabilization of the glass mass in the feeder at the temperature of 1250-1450°C and fiber making through feeders, drawing off through draw plates, fibers greasing and reeling into bobbins. Basalt is preliminary heated up to 150-900°C before batching into the furnace and melted glass mass is kept in the stabilizing zone of the smelting furnace up to the temperature of the fiber making, equal to $t_{nnae} + (50 - 250°C)$. Device for basalt fiber making includes basalt batcher, smelting furnace, feeder with drain system, feeders, draw plates, mechanisms for grease application and reeling fiber into bobbins. At the same time basalt batcher is equipped with the heat exchanger, connected with the combustion space of the smelting furnace; and smelting furnace has a glass mass stabilizing zone which is connected with the feeder; stabilizing zone height is 0.4-0.6 of the smelting furnace bath height. The problem of expanding the range of basalt rocks used for production [2 f, 7 tables, 1 fig].
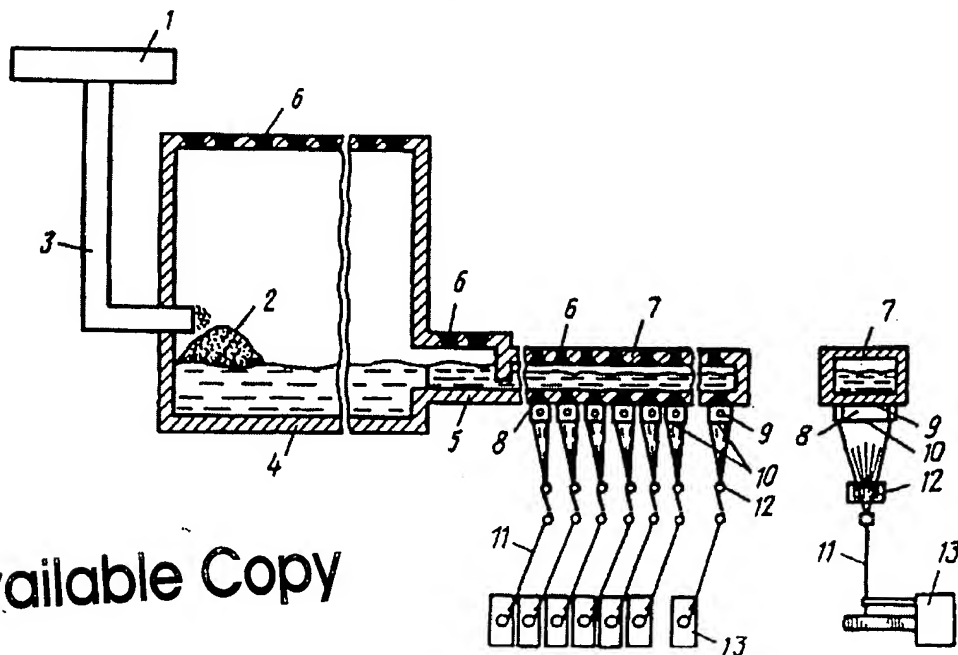
This invention is related to production of the mineral fiber from the natural material of basalt group (basalts, andesite basalts, andesites, gabbro etc.) which can be used in construction, textile and chemical industry.

There are three general types of compounds of the basalt group rocks. The first type – compound of the rock, enriched with Fe and Ti oxides (~70% Fe_2O_3 and 20% TiO_2). The second type – basalt rocks, enriched with Al and Si oxides (~25% Al_2O_3 and 55% SiO_2). The third type – basalt rocks, enriched with Mg, Ca and Fe oxides (~12% MgO, ~20% CaO and 10% Fe_2O_3). All these compounds are meant for basalt fiber production. However, to make a high quality, chemical resistant, temperature resistant fiber, the compound of the basalt rock is limited in the oxides content. For instance, for the basalt fiber production a glass, containing the following oxides is used: SiO_2, Al_2O_3, TiO_2, Fe_2O_3, FeO, MnO, CaO, MgO, K_2O, Na_2O, SO_3, P_2O_5, Se_2O_3, ZnO with the components ratio $\dfrac{Al_2O_3}{CaO + Mg} < 2.0$ which guarantees an improved stability to acids and expansion of the production temperature interval [1].

However, a mentioned glass compound allows reaching of high technological parameters only in case of the high Al_2O_3 content and in the fixed temperature range, that limits usage of basalts of the other type (with different components ratio) and excludes a possibility to produce a high-quality, stable to acids and alkali, high-temperature resistant fiber.

The process of fiber production from each type of the glass mass requires specific production technology.

Most similar in the engineering essence to the proposed method is the method of the basalt fiber production, which includes batching, melting of the basalt in the furnace bath, supply of the melt into the feeder and stabilizing the melt, making fiber through the feeder and drawing off through the draw plates, greasing of the fiber and reeling it in bobbins [2].

Disadvantages of the known technologies are insufficiently high quality of the fiber at the low level of output and complexity of production due to necessity of complex preparation of the basalt rock; necessity in the high temperature interval in the melting furnace; long glass mass stabilization period which cause possibility of its crystallization (and, hence, vitrifying) on the surface of draw plates.

Technological objective is to expand the range of basalt rocks used for production with reduction of the production cycle, improving stability of the process and increasing strength, corrosion and temperature stability of the fiber.

Technological objective is solved in the following way, in the method, which includes batching of basalt into the smelting furnace, its melting, glass mass stabilization in the feeder at the temperature of 1250-1450°C and fibers production through feeders, drawing off through draw plates, fibers greasing and reeling in bobbins, in accordance with invention, before batching into the furnace, basalt is heated to the temperature of 150-900°C, and melted glass mass is kept in the stabilization zone of the smelting furnace up to the temperature of the fiber making, equal to $t_{nnae} + (50 - 250^{\circ}C)$ (where t_{nnae} – temperature interval of basalt rocks melting), after that it is stabilized in the feeder in order to obtain a glass mass compound with the following ratio of main components:

$$\frac{Al_2O_3 + SiO_2}{CaO + MgO} \geq 3;$$

$$\frac{FeO}{Fe_2O_3} \geq 0.5;$$

$$\frac{2Al_2O_3 + SiO_2}{2Fe_2O_3 + FeO + CaO + MgO + K_2O + Na_2O} \geq 1.5$$

And device for basalt fiber making, which includes basalt batcher, smelting furnace, feeder with drain system, feeders, draw plates, mechanisms for grease application and reeling fiber into bobbins, in accordance with invention, basalt batcher is equipped with heat exchanger, connected with the combustion space of the smelting furnace; and smelting furnace has a glass mass stabilizing zone which is connected with the feeder; stabilizing zone height is 0.4-0.6 of the smelting furnace bath height. The proposed method differs from the known one in preliminary heating to the temperature of 150-900°C, which provides drying, extraction of crystallized water and uniformity of basalt heating in the whole volume and reduce the melting temperature interval. At the same time an output of the smelting furnace increases. Moreover, a melted glass mass is kept in the kept in the stabilizing zone of the smelting furnace up

to the temperature of $t_{nnas} + (50 - 250^\circ C)$, which provides extraction of blebs, froth and, at the same time, the glass mass volume stabilizes, melt surface becomes plane and smooth and temperature of the glass mass melt uniformly comes down in the whole volume of the melt to the temperature of fiber making that makes possible to reduce time of melt stabilizing in the feeder and average over a mass, and secure a following ratio of components in the glass melt:

$$\frac{Al_2O_3 + SiO_2}{CaO + MgO} \geq 3;$$

$$\frac{FeO}{Fe_2O_3} \geq 0.5;$$

$$\frac{2Al_2O_3 + SiO_2}{2Fe_2O_3 + FeO + CaO + MgO + K_2O + Na_2O} \geq 1.5$$

These ratios secure stability of the temperature interval and viscosity, required for the fiber production.

The proposed device for the process accomplishment differs in presence of the heat exchanger in the basalt batcher, which provides a uniform heating of basalt in the whole volume with the flow of hot air from the combustion space of the smelting furnace that allows utilizing of the waste gasses and reducing of the fuel consumption. Presence of the melted glass mass stabilizing zone, with the height of 0.4-0.6 of the smelting furnace bath height, secures a melts stabilization in the volume when it leaves a furnace with the fixed temperature. The stabilizing zone height depends on the melts height and possibility of gas and froth discharge.

Device for the basalt fiber production method is shown on the diagram.

The device includes batcher (1) for basalt (2) batching, heat exchanger (3), connected with the combustion space of the smelting furnace (4). The smelting furnace (4) has a glass mass stabilizing zone (5) where the melted glass mass is stabilized in the volume up to the temperature of basalt fiber making. The smelting furnace (4) and stabilizing zone (5) are equipped with the heating systems (6). Stabilizing zone (5) of the smelting furnace (4) is connected with feeder (7), where melt is stabilized till averaging-out a melt mass and securing the components ratio in the mixture. Feeder (7) has drain system (8) and feeders (9), feeding melt to the draw plates (10), through which basalt fiber (11) is drawn off and fed to the mechanism of grease application (12) and then reeled in bobbins (13).

The basalt fiber production method is accomplished in the following way. Basalt rocks of compounds shown in tables 1-4 are used.

Basalt rocks are preliminary purified from admixtures, grinded into the powdery state and is batched into the smelting furnace (4) through the batcher (1). At the same time, batcher is connected with the heat exchanger (3) where basalt rock (2) is heated up to the temperature of 150-900°C with the hot air, discharged from the combustion space of the furnace (4). Heated basalt rocks are fed into the smelting furnace (4) where they are melted at the temperature of 1450±50°C up to melting and forming of the glass mass. After that the glass mass melt gets into the stabilizing area of the smelting furnace (4), where melt is stabilized due to its restricted height and temperature is reduced to the temperature of fiber making $t_{nnas} + (50 - 250^\circ C)$. In the section 5 blebs and froth are extracted, melt surface becomes plane, smooth and calm. The smelting furnace (4) and stabilizing area (5) are equipped with heating systems (6). From the stabilizing section (5) partially stabilized glass mass melt comes into the feeder (7) for mixtures averaging-out and obtaining a compound, required for the fiber making. Feeder (7) is also equipped with heating systems (6) in order to maintain the temperature interval of the fiber making in the range of 1350-1450°C and viscosity 60-240 Pa·sec.

Examples of the glass mass compounds and processing conditions for the fiber making are listed in tables 5, 6.

From the feeder (7), by means of the stream feeder (8) the glass mass melt is fed to feeders (9) and draw plates (10); elementary threads are drawn off, greased by means of the mechanism (12) and reeled into bobbins (13).

Physical-mechanical properties of basalt fibers are given in the table 7.

From the table 7 it is clear that proposed method and device for its accomplishment makes possible to produce high-strength, corrosion and temperature stable continuous fiber from basalt rocks of various types and simplify the production technology.

SUBJECT OF AN INVENTION

1. Method of the basalt fiber production, *including* basalt batching into the smelting furnace, its melting, glass mass stabilizing in the feeder at the temperature of 1250-1450°C and fiber making through draw plates, fiber greasing and reeling into bobbins, which *differs* in preliminary heating of the basalt up to the temperature of 150-900°C prior its batching into the smelting furnace and melted glass mass is kept in the stabilizing area of the smelting furnace up to the temperature of fiber making equal to $t_{nnae} + (50 - 250^{\circ}C)$; after that it is stabilized in the feeder up to obtaining the glass mass mixture with the following ratio of main components

$$\frac{Al_2O_3 + SiO_2}{CaO + MgO} \geq 3;$$

$$\frac{FeO}{Fe_2O_3} \geq 0.5;$$

$$\frac{2Al_2O_3 + SiO_2}{2Fe_2O_3 + FeO + CaO + MgO + K_2O + Na_2O} \geq 1.5$$

where:

t_{nnae} – temperature interval of basalt rocks melting

2. The device for basalt fiber production, *including* basalt batcher, smelting furnace, feeder with drain system, feeders, draw plates, mechanisms for grease application and reeling fiber into bobbins, which *differs* in: the basalt batcher is equipped with the heat exchanger, connected with the combustion space of the smelting furnace; and smelting furnace has a glass mass stabilizing zone which is connected with the feeder; stabilizing zone height is 0.4-0.6 of the smelting furnace bath height.

Table 1

Mixture no.	Content of the rock base									
	Na	*Mg*	*Al*	*Si*	*K*	*Ca*	*Ti*	*Mn*	*Fe*	*P*
1	4.567	0.232	11.537	32.932	2.426	1.428	12.771	0.240	33.968	–
2	0.415	13.552	1.153	51.318	0.184	21.752	1.320	0.309	9.999	–
3	6.573	0.358	20.340	60.648	4.873	2.088	1.506	0.001	2.689	0.326
4	3.513	4.067	11.235	44.778	2.670	7.883	5.325	0.474	19.651	0.454
5	5.744	0.465	19.541	56.221	4.503	3.924	2.889	0.180	5.642	0.890

Table 2

Mixture no.	Content of coarse impurities									
	Na	*Mg*	*Al*	*Si*	*K*	*Ca*	*Ti*	*Mn*	*Fe*	*P*
1	5.420	0.352	26.824	54.104	0.481	10.875	0.330	0.061	1.552	0.00
2	6.672	0.000	20.207	64.108	6.410	1.540	0.300	0.024	0.489	0.248
3	1.425	13.499	2.304	50.003	0.166	19.882	1.917	0.216	10.279	0.371
4	0.984	0.685	24.053	56.550	4.568	8.310	2.847	0.031	1.992	0.00
5	4.160	1.859	17.890	58.470	4.688	5.817	0.497	0.245	6.378	0.00

Table 3

Mixture no.	Content of fine impurities									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1	5.775	0.413	18.112	63.813	8.139	1.459	0.132	0.000	2.156	0.000
2	11.614	2.263	22.164	55.601	0.260	2.243	0.159	0.098	3.819	1.776
3	0.422	1.364	0.817	0.830	0.086	0.214	23.541	1.226	71.502	0.000
4	0.371	2.138	1.035	0.627	0.095	0.060	20.530	0.796	72.217	0.134
5	0.725	13.683	1.364	49.475	0.187	20.085	2.023	0.250	13.121	0.087

Table 4

Mixture no.	Averaged content of the basalt									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1	6.325	1.970	17.833	55.903	4.558	4.672	1.582	0.160	6.997	0.000
2	5.083	7.932	14.127	46.154	2.320	4.697	1.343	0.396	16.461	1.512
3	5.887	2.773	17.493	53.716	3.923	4.867	1.299	0.098	8.276	1.680
4	4.357	3.187	17.660	52.501	3.927	5.515	1.701	0.155	8.541	1.953
5	4.404	3.470	15.324	51.606	2.810	7.681	1.852	0.185	9.223	2.944

Table 5

Mixture no.	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P	$\dfrac{Al_2O_3 + SiO_2}{CaO + MgO}$	$\dfrac{FeO}{Fe_2O_3}$	$\dfrac{2Al_2O_3 + SiO_2}{2Fe_2O_3 + FeO + CaO + MgO + K_2O + Na_2O}$
1	2.00	10.58	11.82	50.42	0.52	3.94	1.04	8.18	12.25	0.21	3.2	3.34	2.0
2	2.34	5.47	12.58	49.03	0.66	9.53	2.85	0.32	14.03	0.30	4.11	2.62	2.06
3	3.88	4.65	16.75	50.61	1.0	9.07	1.81	0.18	10.26	0.40	4.9	0.54	2.37
4	2.93	5.39	14.89	50.15	0.34	8.32	2.04	0.22	12.05	1.98	4.39	1.52	2.37
5	4.75	3.54	15.33	49.66	3.10	6.56	2.34	0.21	12.05	1.98	6.44	1.62	2.39

Table 6

Mixture no.	The upper limit of crystallization $T_{ВПК}$, °C	Diameter of the fiber μm	Temperature interval of fiber making $T_{ИВВ}$, °C	Viscosity interval at the temperature $T_{ИВП}$ $Pa \cdot sec$
1	1290	8.4-12	1360-1400	104-62
2	1275	7.0-13	1380-1440	112-64
3	1240	7.0-11	1370-1450	188-88
4	1250	7.0-12	1350-1440	235-96
5	1245	7.0-12	1350-1430	235-104

Table 7

Strength and chemical stability of the fiber

Mixture no.	Diameter of the fiber, μm	Tensile strength, MPa	Chemical stability % after 3 hours boiling			
			H_2O	NaOH		HCl
			–	0.5H	2H	2H
1	10.2	2400	99.3	92.6	85.3	75.8
2	10.0	3110	99.4	97.5	94.0	80.6
3	9.0	2240	99.5	98.2	95.2	91.0
4	9.5	3050	99.4	97.6	96.8	90.1
5	3.5	3100	99.4	94.1	92.5	83.5